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Dated 23 September 2004

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28NOV03 E855707-4 001607
P01/7700 0.00-0327671.4

1/77

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

P/7003

2. Patent application number
(The Patent Office will fill in this part)

0327671.4

28 NOV 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Corac Group PLC
Brunel Science park
Kingston Lane
Uxbridge
Middlesex UB8 3PQ
United Kingdom

Patents ADP number *(if you know it)*

8137085001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

Gas Seals for Rotary Machines

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

A. Messulam & Co. Ltd.
43-45 High Road
Bushey Heath
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HERTS WD23 1EE

Patents ADP number *(if you know it)*

07636210001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
GB	0306402.9	20 March 2003

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	None
Description	7
Claim(s)	1
Abstract	1
Drawing(s)	1

10. If you are also filing any of the following, state how many against each item.

Priority documents	We hereby withdraw the parent application and request that its papers be used in lieu of priority documents
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	Yes
Request for preliminary examination and search *(Patents Form 9/77)*	Yes
Request for substantive examination *(Patents Form 10/77)*	No
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature

Date 27 November 2003

12. Name and daytime telephone number of person to contact in the United Kingdom: A. Messulam (020 8421 8197)

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

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Patents Form 7/77

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7/77 NGH

030EC03 B149485-1 D01607
P07/7700 0.00-0327671.4

Statement of inventorship and of right to grant of a patent

THE PATENT OFFICE
J
- 3 DEC 2003
NEWPORT

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference	P/7003
2. Patent application number *(if you know it)*	0327671.4
3. Full name of the or of each applicant	Corac Group PLC
4. Title of the invention	Gas seals for rotary machines
5. State how the applicant *(s)* derived the right from the inventor *(s)* to be granted a patent	By virtue of the employment of the inventor
6. How many, if any, additional Patents Forms 7/77 are attached to this form? *(see note (c))*	None
7.	I/We believe that the person *(s)* named over the page *(and on any extra copies of this form)* is/are the inventor *(s)* of the invention which the above patent application relates to. Signature: A Messulam — Date: 2 December, 2003
8. Name and daytime telephone number of person to contact in the United Kingdom	A. Messulam (020 8421 8197)

Notes

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Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

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Reminder

Have you signed the form?

GAS SEALS FOR ROTARY MACHINES

Field of the invention

The present invention relates to seals for restricting leakage of a fluid about a shaft extending through a housing, such as in a compressor or a turbine, and in particular for restricting leakage of gas at elevated pressure.

Background to the Invention

Gas seals are currently used widely to seal process gases in large rotary machines such as turbo compressors and associated turbo machinery. The industry has adopted as its standard, an arrangement of sealing cartridge which is comprised of a stacked assembly that can be slipped on to the end of the rotor.

The most common type of gas seal in current use is a tandem seal, as shown in section in Figure 1 of the accompanying drawings. A similar seal is shown, for example, is Figure 3 of US 5,412,977. The cartridge comprises two stages, namely an inboard stage 10 and an outboard stage 12. The inboard stage 10 is used to seal the complete process gas pressure. The outboard stage 12 is also engineered to be capable of sealing the complete process gas pressure. However, during normal running, it is only exposed to around 5-15 bar of gas pressure, its main function being to act as a back up to the inboard stage 10. Should the inboard stage 10 suffer catastrophic failure during operation, the outboard stage 12 takes on the full sealing function and enables the compressor to be run down, stopped and the process gas pressure vented in a controlled manner.

Each stage 10, 12 comprises a primary ring 14 mounted in a retainer and balance diameter assembly 18 in the

machine casing. A spring 20 within the assembly 18 acts on the primary ring 14 through a pressure plate 22 that is sealed relative to the stationary assembly housing. The spring 20 urges the primary ring towards a mating ring 16 that rotates with the machine rotor 30.

The primary ring 14 has axial end faces which are exposed to the pressure of the process gas and have different surface areas. The primary ring 14 therefore acts as a differential piston on which the pressure of the process gas exerts a force in the direction to compress the spring 20. In operation, an equilibrium occurs between the gas pressure forces and the spring force when there is a small gap between the primary and the mating rings 14 and 16. This gap prevents the wear to the surfaces of the rings 14 and 16 while limiting escape of the process gas to a small and acceptable leakage.

The manner in which a gas seal operates and the details of its construction, such as the choice of materials to make the rings, are well known in the art and need not therefore be described further in the context of the present invention.

In the known seal cartridges, the two sealing stages are mounted on a common support sleeve 40. The inner surface of the sleeve 40 and the outer surface of the rotor 30 are stepped so as to limit the extent to which the sleeve can move to the left, as viewed in Figure 1, relative to the rotor 30. A single locknut 42 on the rotor 30 is therefore all that is required to clamp the support sleeve 40 on the rotor 30. This allows both the sealing stages 10 and 12 to be released from the machine by removal of one locknut 42. At one end, the support sleeve 40 has a radial flange 44 which carries the mating ring 16 of the inboard stage 10. The mating ring 16 is held against the flange 44 of the support sleeve 40 by a spacer sleeve 50 which itself has a

radial flange 52 which carries the mating ring 16 of the outboard stage. An O-ring seal 54 seals between inner surface of the spacer sleeve 50 and the outer surface of the support sleeve 40. A locking sleeve 60 clamps the mating ring 16 of the outboard stage 12 against the flange 52 of the spacer sleeve 50 and its inner surface is also suitably sealed relative to the outer surface of the spacer sleeve 50.

The above described construction of a tandem seal is convenient in that it allows for easy replacement of both stages of the seal and it enables a compact construction in that the entire cartridge is held in place by only one locknut.

The present invention is however predicated on the recognition of the fact the prior art construction of a tandem gas seal also has serious disadvantages. As earlier explained, it is quite common for only one stage to fail but the known construction does not allow the different stages to be worked on independently. Thus, in the embodiment illustrated in Figure 1, in order to access the inboard stage, it is necessary to dismantle the entire outboard stage, which may not itself require attention. Many other problems can be identified, and are discussed in more detail below, which stem from the fact that the two stages cannot function separately.

Summary of the invention

With a view to mitigating the foregoing disadvantages, there is provided, in accordance with a first aspect of the invention, a tandem gas seal assembly for sealing between the rotor and the casing of a rotary machine which comprises two sealing stages for mounting axially adjacent one another on the machine rotor, wherein the two stages are totally

separable from one another and each is capable of functioning as a seal when separated from the other.

Preferably, mating formations are formed at the adjacent axial ends of the two sealing stages to maintain the two stages in axial alignment with one another.

The mating formations may suitably include an annular collar projecting axially from the end of one of the stages and fitting over a cylindrical end region of the other sealing stage. An O-ring is advantageously provided as a means for centring the mating formations of the two sealing stages.

Even though the sealing stages are independent of one another, they are preferably stacked one against the other and retained on the rotor by means of a single locknut acting on the outboard stage. There is thus no need to sacrifice the advantages offered by prior art construction with regard to space saving and the ease of mounting and dismounting of the seal assembly on the rotary machine.

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is as earlier described a section through a known tandem seal assembly cartridge, and

Figure 2 is a similar section to Figure 1 showing a tandem seal assembly embodying the invention.

Detailed description of the preferred embodiment

In the present invention, the inboard and outboard stages of a tandem seal are constructed as totally separate modules, each containing the components of one the sealing stages of the known tandem seal shown in Figure 1. In order

to avoid unnecessary repetition, like components have been allocated like reference numerals and will not be described a second time. Components which serve the same function but have been modified have also been allocated the same reference numerals but a prime has been added to show that the component has been changed.

In general, the components secured to the casing of the rotary machine have not been changed and they operate in exactly the same way as earlier described. The important changes are the following:

- There are two support sleeves 40' associated with the two stages 10 and 12 instead of a single support sleeve 40 common to the two stages.
- The radial flange 52' supporting the second mating ring 16 is not formed on a spacer sleeve 50 but directly on the second of the two support sleeves 40'.
- The spacer sleeve 50 is not used to hold the mating ring on the annular flange 44' of the support sleeve 40' and this function is instead performed by a second locking sleeve 60' analogous to the locking sleeve 60 of the outboard stage 12 in Figure 1.

The above modifications result in a total separation of the two sealing stages and each can now function totally independently of the other. In other words, they do not need to be placed next to one another for them both to function normally. It is preferred to mount them next to each other, as illustrated because they can then be retained using a single locknut 42 on the rotor 30, as previously.

Though it is possible to rely exclusively on the rotor to maintain the two stages in correct alignment, it assists assembly and improves structural rigidity to provide mating formations on the axial ends of the two stages to maintain them in correct axial alignment and to provide a seal between the two stages. In the illustrated embodiment of

the invention, the mating formations comprise an annular collar 70 projecting from the axial end of the support sleeve of the outboard stage surrounding a cylindrical surface defined by the end of the locking sleeve 60' of the inboard stage, the seal between the two being effected by an O-ring 72.

The separation of the sealing stages into separate modules offers several advantages, which will now be discussed.

- Each of support sleeves is shorter in length for the same given diameter thus providing, improved structural integrity.
- Separation of the stages allows each to be dynamically balanced independently of the other, improving both the ease and the quality of the balancing.
- The modular arrangement, enables independent replacement of just one module, be it the inboard or the outboard stage. This significantly reduces down time.
- Any refurbishment, repair, or replacement need only be done on one module, without having to strip the other.
- Less metal is required during the manufacture as compared with a conventional tandem seal cartridge. This is because the support sleeve 40, for example, needs to be machined from a long blank having a diameter greater than that of the radial flange 44 and the spacer sleeve needs to be machined from a second blank of nearly the same size. By contrast, in the seal assembly of the present invention, the two support sleeves 40' can be machined out of a blank of approximately the same size as that required for the support sleeve 40. Aside from starting with less metal, the manufacturing process also requires less metal removal and is therefore significantly less time consuming and costly.
- The assembly procedure is simplified, resulting in reduced assembly time and reduced assembly costs.

- The modular arrangement enables much more rapid fault diagnosis on test, thus further reducing time and costs. The fact that there are no shared components means that a fault can be more easily located in one or other of the modules and each can be tested separately from the other.

CLAIMS

1. A tandem gas seal assembly for sealing between the rotor and the casing of a rotary machine which comprises two sealing stages for mounting axially adjacent one another on the machine rotor, wherein the two stages are totally separable from one another and each is capable of functioning as a seal when separated from the other.

2. A gas seal assembly as claimed in claim 1, wherein mating formations are formed at the adjacent axial ends of the two sealing stages to maintain the two stages in axial alignment with one another.

3. A gas seal assembly as claimed in claim 2, wherein the mating formations include an annular collar projecting axially from the end of one of the stages and fitting over a cylindrical end region of the other sealing stage.

4. A gas seal assembly as claimed in claim 2 or 3, wherein means are provided for effecting a gas tight seal between the mating formations of the two sealing stages.

5. A gas seal assembly as claimed in any preceding claim, wherein each of the sealing stages is dynamically balanced separately from the other.

6. A rotary machine having a rotor, a casing and a tandem gas seal as claimed in any preceding claim mounted between one end of the rotor and the casing, wherein the two sealing stages directly abut one another and are retained on the rotor by means of a lock nut applying an axial force to only the outer of the two sealing stages.

ABSTRACT

GAS SEALS FOR ROTARY MACHINES

A tandem gas seal assembly is described for sealing between the rotor and the casing of a rotary machine. The assembly comprises two sealing stages 10, 12 mounted axially adjacent one another on the machine rotor. In the invention, wherein the two stages 10 and 12 are totally separable from one another and each is capable of functioning as a seal when separated from the other.

Figure 2.

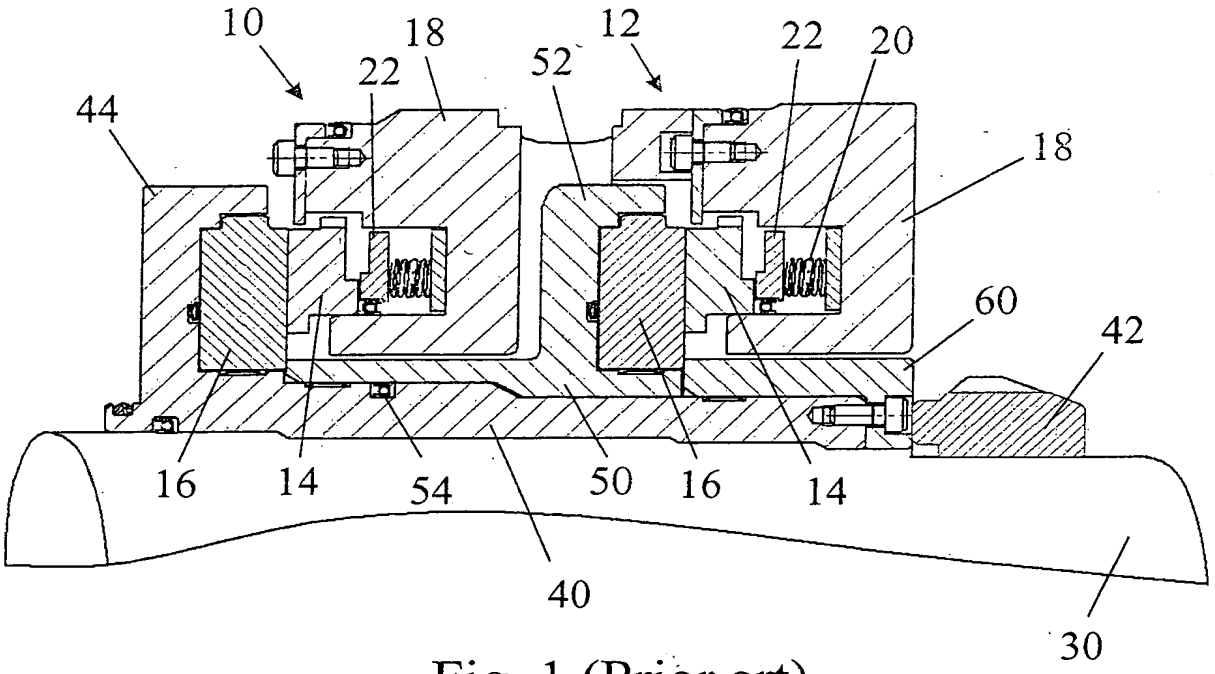

Fig. 1 (Prior art)

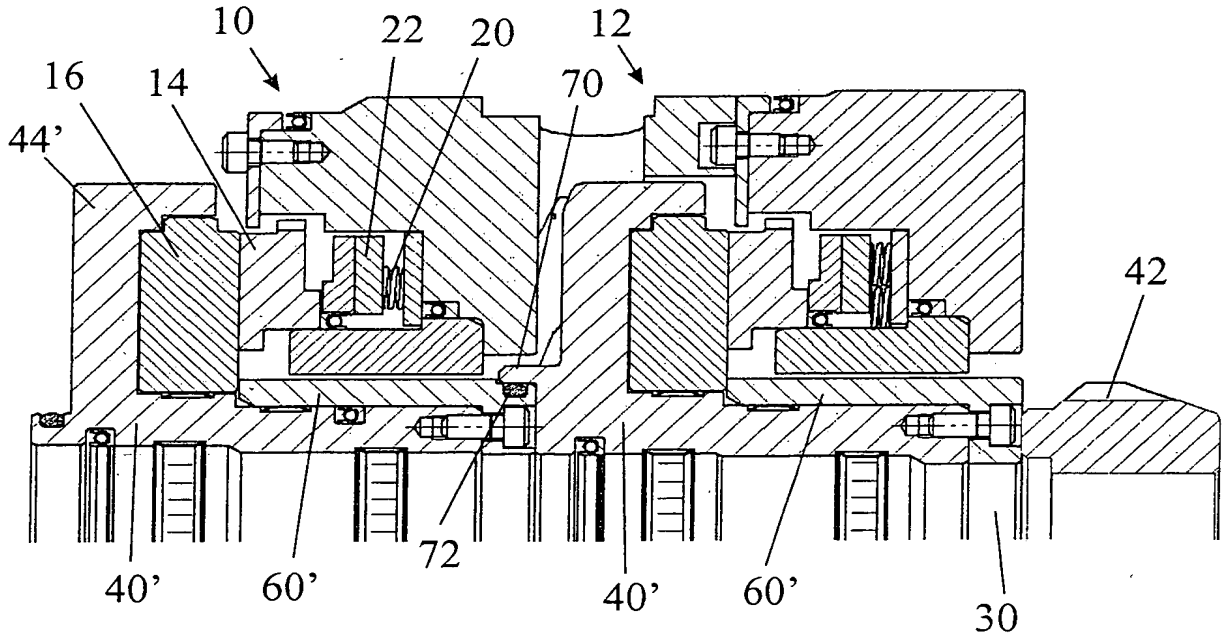

Fig. 2